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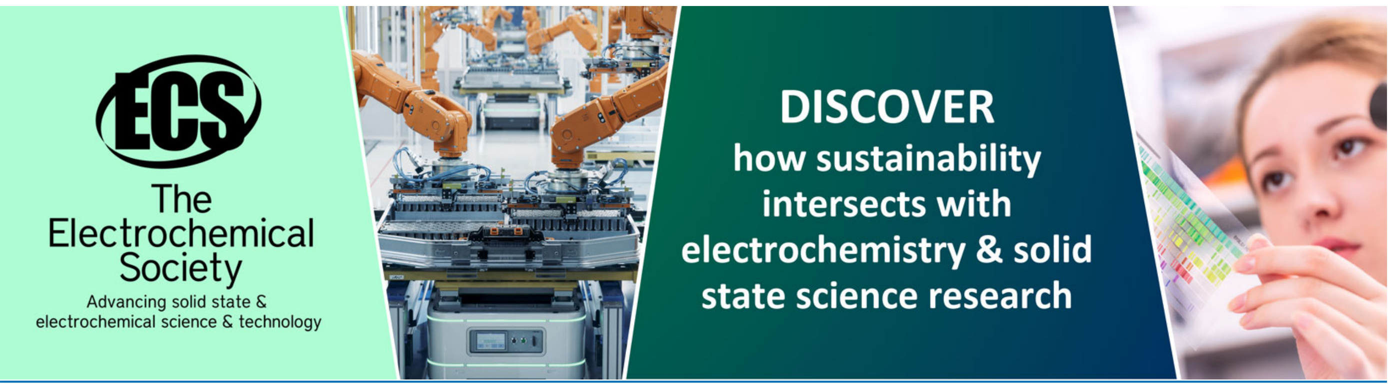

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Correlation between Left Ventricular Function with Functional Capacity in Post Infarct Myocard Patients with Heart Failure

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Abstract. In myocardial infarct patient with heart failure, left ventricular (LV) function evaluation after myocardial infarction provides prognostic information. However, the relationship between exercise capacity and LV function has not been fully explored. This study aims to analyze the correlation of LV function with functional capacity in acute myocardial infarct patient with heart failure. From 33 patients who fulfilled the inclusion and exclusion criteria, treadmill and echocardiography were examined (LVEDd, myocardial performance index (MPI), E/E 'diastolic function, LV Stiffness). The results are then statistically analyzed using SPSS. The mean LV ejection fraction is 44.27 ± 9.0% by Teich, and 40.55 ± 8.3% by Biplane. The value of the global MPI function is (0.60-0.90). The average E/A ratio is 1.0 ± 0.5, deceleration time (DT) is > 220m / sec, and E / E ratio is 11.46 ± 5.82ms. The functional capacity value is 3.4 (1.1-8.4) METS. There is a significant positive correlation of LV systolic function and functional capacity and significant negative correlation between MPI and functional capacity in myocardial infarct patients with heart failure. Furthermore, there is a non-significant correlation between diastolic function and functional capacity.

1. Introduction

Cardiovascular disease is still a substantial health problem in both developed and developing countries. Every year an estimated 1.5 million people experience acute myocardial infarction. The World Health Organization (WHO) shows deaths due to coronary artery disease (CAD) in the top ranks of 12.2% in 2004 and 14.2% in 2008. Indonesia's 2009 health profile issued by the Ministry of Health of the Republic of Indonesia also shows that CAD ranks highest, namely 11.06% of causes of death in hospitals in 2008 [1].

CAD is a significant cause of heart failure. Some epidemiological studies show the numbers vary between 36% to 60% of CAD as the primary cause of heart failure. The onset of heart failure is linked to the degree of myocardial injury and the left ventricular (LV) remodeling process after myocardial infarction. After myocardial infarction, there will be a disruption of the heart muscle contractile tissue and changes in ventricular geometry. This will affect ventricular systolic and diastolic functions. Chuwa Tei presents an index that combines systolic and diastolic functions as a global performance index of ventricular myocardial called myocardial performance index (MPI). This index, according to several studies, correlates well with measurements of invasive left ventricular diastolic and systolic functions [2][3].

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In CAD patients, impaired exercise capacity is widespread and is related to elevated cardiovascular mortality. After infarction, the metabolic equivalent for task (MET) level or duration of training achieved is a sound predictor of future cardiac events. The total rate of one-year post-infarct mortality increases by 1.5% to 3.4% in patients with impaired exercise tolerance. The highest mortality rates in post-infarction studies were found in a subset of patients who were unable to carry out a training test at all.

The relationship between exercise capacity and LV function has not been fully explored. The normal or near-normal capacity of exercise is generally considered to describe normal LV function. Previous studies have shown a weak correlation between the index of peak aerobic capacity and LV systolic function. In contrast, the latest report underlines the significance of LV diastolic function to preserve exercise capacity, not only in hypertrophic cardiomyopathy with preserved ejection fraction and hypertension patients, but also in myocardial infarction with dilated cardiomyopathy and impaired systolic function [4].

Based on the background above, the researchers hypothesized that impaired LV function during exercise could estimate functional capacity in patients with LV dysfunction caused by myocardial infarction.

2. Methods

2.1 Research Design

This prospective cross-sectional study was conducted in 33 heart failure patients resulting from CAD, taken from the cardiac outpatient care at Dr. Soetomo Hospital in Surabaya from September 2014 to November 2014. All patients were willing to participate in the study and signed the informed consent. Sample inclusion criteria include male or female aged ≥45 years, with a history of acute myocardial infarction at least three months before with New York Heart Association (NYHA) functional class II-systolic heart failure, willing to participate in research and sign an informed consent.

Exclusion criteria include not able to walk or run without the help of others, there are contraindications for carrying out load training tests, suffered from acute coronary syndrome within three months of the start of the study, electrocardiographic recordings show images of atrial fibrillation, using a permanent pacemaker, NYHA functional class III-IV heart failure, severe mitral regurgitation, chronic obstructive pulmonary disease (COPD) sufferers, and obesity.

2.2 Echocardiography

The echocardiography tool used in this study is GE Medical System Vivid 7 pro class I type CF. This tool is used to assess LV function. An examination is done by combining pulsed wave methods, Doppler tissue, and M-mode. Examination of pulsed wave Doppler (PWD) in the mitral inflow is performed at the apical four-chamber position, with the direction of the volume flow of the sample on the leaf tip of the mitral valve parallel to the Doppler cursor.

2.3 New York Heart Association (NYHA) Classification

NYHA classification is based on patient clinical findings. Patients were interviewed and then examined physically. NYHA class I is when the patient does not indicate the limit of shortness of breath when carrying out physical activity while Class II is having a few restrictions on physical activity, but is ease at rest. NYHA Class III is marked by restrictions on physical activity even if it is less than a normal activity, but still comfortable at rest, whereas class IV is marked by appearance of signs and symptoms even at rest.

2.4 Electrocardiogram (ECG)

An ECG examination was performed to assess evolutionary changes in the ECG series to suspect myocardial infarction.

2.5 Statistical Analysis
IBM SPSS Statistics 20.0 was used to analyse the data statistically. Data were considered significantly different if p <0.05. Continuous variables were evaluated for normal distribution, presented as mean ± SD. Pearson's analysis evaluated the correlation between variables. Linear logistic regression is used to measure the odds ratio. Receiver operating characteristic (ROC) curve analysis was carried out to identify specificity and sensitivity.

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3. Results

Table 1. Characteristics of research subjects.

Variable	Average ± SD
Age (years)	58.45±6.2
Long suffering from myocardial(months)	9.45±5.3
BMI[a] (kg/m^2)	24.07±3.2
Sistolic BP[b] (mmHg)	134.85±17.3
Diastolic BP[b] (mmHg)	84.39±9.7
Pulse (times/minutes)	76.76±13.9
Men	23 (69.7)
Diabetes mellitus (DM) type 2	14 (42.4)
Hypertension	20 (60.6)
Dyslipidemia	14 (42.4)
Smoke	17 (51.5)
NYHA[c]:	
Kelas I	12 (36.4)
Kelas II	21 (63.6)
Total Cholesterol (mg/dl)	188.48±42.6
Triglyceride levels (mg/dl)	132.73±61.7
HDL[d] (mg/dl)	40.73±10.7
LDL[e] (mg/dl)	117.6±31.3

[a]Body Mass Index
[b]Blood Pressure
[c]New York Heart Association
[d]High-Density Lipoprotein
[e]Low-Density Lipoprotein

Table 2 below shows the descriptive parameters of the echocardiography subject research. The mean value of LV ejection fraction (EF) of the study sample is 44.27±9.0% by Teich, and 40.55±8.3% by Biplane. This decreases EF value linear with the value of the global MPI function indicates moderate dysfunction (0.60 - 0.90).

Table 2. Echocardiographic parameters of research subjects.

Variable	Average ± SD
EF by Teich (%)	44.27±9.0
EF by Biplane (%)	40.55±8.3
E/A	1.0±0.5
DT (m/detik)	221.79±71.1
E/E'	11.46±5.82
LV stiffness	0.18±0.1
MPI	0.63±0.2

Notes:MPI : myocardial performance index

Table 3. Correlation analysis of left ventricular function with functional capacity (n=33).

Variable	Median (Minimum-Maximum)	p	r
EF Teich	47 (23-66)	0.075*	0.314
EF Biplane	42 (21-52)	0.003*	0.507
E/A	0.77 (0.34-2.72)	0.,333**	-0.174
DT	253 (65-390)	0.253*	0.205
E/E'	10.21 (6.03-24.97)	0.079*	-0.310
LV stiffness	0.17 (0.1-0.38)	0.398*	-0.152
MPI	0.59 (0.40-0.98)	0.007*	-0.463
Functional Capacity (METS)	3.4 (1.1-8.4)		

Notes : MPI : myocardial performance index, METS : metabolic equivalent for task
*Analyzed with *Pearson Correlation Test* (α=0.05)
**Analyzed with *Spearman Correlation Test* (α=0.05)

4. Discussion

More than half of the total study subjects were overweight with an average body mass index (BMI) of 24.07 ± 3.2kg/m^2. In this study, the subjects' inclusion criteria were limited to NYHA I and II only. In contrast to Wierzbowska-Drabik et al. (2009), this difference made the NYHA classification group into NYHA class I-II and NYHA class III-IV [4].

This study showed that systolic dysfunction with a mean left ventricular ejection fraction (LVEF) decreased by 44.27 ± 9.0% by Teich, and 40.55 ± 8.3% by Biplane. There was a significant positive correlation between the systolic function of LVEF by Biplane and functional capacity ($p < 0.05$; $r = 0.507$). This is in agreement with the research put forward by Wierzbowska-Drabik et al. (2009), that there is a significant positive correlation between LVEF and functional capacity ($p = 0.0001$;$r = 0.48$). This fact was also found in the study of Pepi et al. (1999), which suggested that there was a strong correlation between LVEF and functional capacity ($p = 0.00001$; $r = 0.63$) [4].

This is in accordance with the theory that, in post-myocardial infarction patients, there is a decrease in volume as a result of myocardial cell death, thus disrupting contractility assessed through LVEF, resulting in decreased oxygen uptake and exercise tolerance. Unlike LVEF by Biplane, LVEF by Teich shows a positive correlation that is not significant with functional capacity. This is due to the condition of irregular left ventricular geometry or regional disturbances in IMA patients so that the value does not indicate the overall left ventricular systolic function. Diastolic dysfunction, i.e., the average E / A ratio is normal or pseudonormal, which is 1.0 ± 0.5. The average deceleration time (DT) indicates abnormal relaxation (DT> 220m / sec), while the average E / E ratio 'is 11.46 ± 5.82ms.

In a Polish study, it was found that the E / A values in the NYHA I-II and NYHA III-IV groups were 0.9 ± 0.4 and 1.4 ± 1.1, respectively. While the value of early deceleration time (Edt) for the NYHA I-II group was 211 ± 66m/ec and NYHA III-IV was 159 ± 63m/sec. When using the cut value 220, then the NYHA I-II group in the study experienced abnormal relaxation, the same results were found in this study [4].

Analysis of LV stiffness showed that there was a rise in LV stiffness in this study ($\beta \geq 0.015$/mL). Similar results were also found in a research by Sinning et al. (2011) in Germany, of 39 patients with heart failure without a decrease in ejection fraction, which was divided into groups with and without diastolic heart failure. The different ejection fractions between the studies by Sinning et al and this study indicate that LV stiffness can occur in normal and decreased ejection fractions heart failure. In the study by Sinning et al., 27 subjects had experienced diastolic heart failure without signs of hypertrophic obstructive cardiomyopathy, hypertrophic cardiomyopathy, and without pseudonormalization. Their research showed that increasing LV stiffness significantly decreases exercise tolerance and breathing reserve, and increases ventilation equivalents against resting CO_2 output and ventilatory threshold. In this study, there were differences in functional capacity between diastolic heart failure groups, and without diastolic heart failure. Thus, it can be concluded that LV stiffness marked as the cardinal mechanism of diastolic dysfunction, which influences exercise intolerance [5]. In our study, there was no difference between subjects with and without impaired diastolic function.

The LV diastolic dysfunction occurrence in acute coronary syndrome is uncertainly known. Some conditions that cause this include myocardial ischemia, fibrosis, and scar due to extensive myocardial infarction. The remodeling results in slowing down of relaxation, impaired distensibility, and increased LV passive stiffness resulting in diastolic dysfunction. Diastolic dysfunction is recognized by abnormalities of the dynamics of LV filling through echocardiography [6].

There are several echocardiographic techniques for evaluating LV diastolic function, one of which is the Doppler technique. Left ventricular diastolic dysfunction is classified into three, namely, abnormal relaxation (grade I), pseudonormal (grade II) and restrictive filling (grade III). The degree of left ventricular diastolic dysfunction is determined based on several deceleration time parameters, E / A ratio, E / E ratio. The worse the degree of left ventricular dysfunction will be, the higher the E /A ratio and the shorter the DT value. In this study, the results were in the form of a non-significant correlation between diastolic function and functional capacity. A negative correlation was found in the relationship between E / A, E / E ', and LV stiffness with functional capacity, whereas it found a positive correlation between DT and functional capacity. Previous studies have shown that there are significant correlations between echocardiographic parameters and functional capacity.

In a Polish study involving 50 people with heart failure who had experienced myocardial infarction, it was found that the diastolic parameters were strongly negatively correlated with the duration of the exercise. The duration of exercise and tolerance was higher in the NYHA I-II group compared to NYHA III-IV [4]. In our study, the research subjects were patients with the classification of NYHA I and II. Because of this limited criteria class, the results of the statistical analysis do not show a significant correlation.

The parameters of global LV function in this study showed moderate dysfunction with a mean MPI value of 0.63 ± 0.2. In this study, we also found a moderate negative correlation, which was significant between MPI global functions and functional capacity ($p < 0.05$; r - 0.463). This result is consistent with the research conducted by Bajraktari et al. (2002), which showed a Tei Index correlation with functional capacity through a 6-minute walk test ($p <0.001$; $r = -0.43$) [7]. MPI has been demonstrated in several previous studies as an independent prognostic factor in the initial phase of myocardial infarction associated with heart failure. This index is significantly susceptible in predicting patients with poor clinical outcomes and has become an independent predictor of cardiac events during hospitalization. In the advanced phase, this index becomes an independent predictor of death, heart failure, and new cardiac events. At the time of acute myocardial infarction, there will be a change in myocardial contraction and relaxation. The contractions and relaxations of myocardial depend on energy so that myocardial dysfunction leads to elongation of isovolumic relaxation contraction time (ICT) and shortening of ejection time (ET). Prolongation of isovolemic relaxation time (IRT) indicates diastolic dysfunction. If systolic and diastolic dysfunction occurs, both may simultaneously produce MPI values.

5. Conclusion

Measurement of myocardial performance, which can, at the same time, include systolic dysfunction and diastolic dysfunction will be a better predictor of the incidence of heart failure. Thus, MPI could be considered as marker of decreased functional capacity and as a predictor of heart failure.

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